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Bank-Specific Daily Interest Rate Adjustment in the Dutch Mortgage Market

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Abstract This paper presents an empirical analysis of the interest rate setting behavior of the four largest banks in the Dutch mortgage market, using advertised interest rates at a daily frequency. The evidence for the long run pricing behaviour suggests that the banks operate in a competitive environment as they base their interest rates on funding cost. However, two banks appear to be less cost sensitive than the others. In the short run, most of the banks adjust their rates less strongly to funding cost increases than to decreases, which suggests competitive pressures. For one bank significant evidence is found for a quicker response to negative than to positive deviations of actual from desired interest rates.

Keywords Asymmetric pricing · Mortgage loans · Error Correction Model

JEL Classification G21 · L13

1 Introduction

The merger wave in European banking during the last two decades has led to some concerns regarding the degree of banking competition. Especially in markets where entry is potentially blocked, due to either legal or economic entry barriers (e.g. high entry costs), competition authorities may face problems in guarding market performance and consumer interests. From an authorities' point-of-view it is essential to

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have insight into the degree of monopoly power in banking markets after this wave of consolidation. A few empirical studies compare banking competition in European countries. For instance Gual and Neven (1993) compare banking costs for consumers across countries. Mojon (2001) observes that the pass-through of monetary policy interest rate changes into money market rates varies across European countries. Corvoisier and Gropp (2002) report differences in retail interest rates across EU countries. Bikker and Haaf (2002) measure banking competition in 23 countries and find that competition is weaker in local and more concentrated markets.

The Dutch banking sector in particular faces concerns regarding financial competition, as is apparent in the initiative of the Dutch competition authority (NMa) to publish a Monitor of the Financial Industry (NMa 2003). In the Netherlands, four large banks (ABN-Amro, Rabobank, Fortis, and ING) together account for about 80% of the market for banking services.[1] In the literature there is some evidence of imperfect competition in the Dutch banking markets. Gual and Neven (1993) find that Dutch consumers face higher banking costs than Belgian, French, and German consumers. As the provision of mortgages in the Netherlands is to a large extent still a local (or regional) activity the concerns with respect to the degree of competition apply specifically to this type of the banking market. Degryse and Ongena (2005) show that geographical distance is an important element in the bank-client relation, which might typically apply to mortgage borrowing. Contrary to this argument one could say that all four banks have a national coverage and so compete in all local communities (as opposed to e.g. Germany). Mojon (2001) argues that the pass-through of official interest rate changes into bank mortgage rates in the Netherlands is about half of the Euro-zone average. This could be caused by the fact that Dutch mortgage contracts have a rather long maturity compared to other European countries. Toolsema and Jacobs (2007), using monthly data on the macro level for the Dutch mortgage market, conclude that there is asymmetric pass-through of funding costs into mortgage interest rates in the sense that Dutch banks tend to increase interest rates instantly when costs rise, while waiting to lower the rates when costs drop. This might lead to serious issues in competition in the banking sector and be of some concern to the supervisor/central bank in the light of transmission of monetary policy.

The contribution of this paper is that the interest rate setting behavior in the Dutch mortgage market is analyzed using daily data on individual banks.[2] Unlike Toolsema and Jacobs (2007), who use macro data on a monthly basis, this study uses *individual* bank data with a *daily* frequency. The setup is as follows. First, the pass-through of funding cost into mortgage rates is tested. The hypothesis tested is that a dominant market player is less cost sensitive and more able to shield profit margins. Next, asymmetric price setting behaviour is tested. The prior tested is that a dominant market player adjusts prices more quickly upwards than downwards.

The data used are daily data on interest rates set by the four largest Dutch banks from October 1997 through July 2003 for mortgage loans with a maturity of 30 years.

[1] ABN-Amro and Fortis have merged on 1 July 2010, after our sample period has ended.

[2] The focus is on interest rate setting and not on the quantities of mortgage loans supplied, because banks are likely to participate in a game of Bertrand price competition instead of Cournot quantity oligopoly (see also Freixas and Rochet 1997).

The interest rate series are for two types of contracts: a contract for which the interest rate renewal period is 5 years and a contract for which this period is 10 years. The interest rates used are the advertised rates, not the effective rates. Although most of these data is public, some banks provided the time-series under the restriction that the name of the bank would be kept anonymous. Therefore the four Dutch banks concerned are hereafter labelled randomly Bank A, B, C and D, respectively.

The results of the analysis indicate that the banks base their interest rates on funding cost. Two banks appear to be less cost sensitive than the others. In the short run, most of the banks adjust their rates less strongly to funding cost increases than to decreases, which suggests competitive pressures. For one bank significant evidence is found for a quicker response to negative than to positive deviations of actual from desired interest rates.

The remainder of the paper is structured as follows. First, Section 2 gives a short description of the Dutch mortgage market. Section 3 reviews some of the theoretical and empirical literature on interest rate pass-through and asymmetric pricing. The econometric methodology is explained in Section 4, the results of which are presented in Section 5. Section 6 concludes.

2 The Dutch market for mortgage loans

2.1 The market

In 2000, the provision of mortgage loans by banks in the Dutch mortgage market accounted for roughly 45–50% of the total market volume (Hassink and van Leuvenstein 2003). The market share of commercial banks in outstanding loans is much larger. In 2002, the total size of outstanding mortgage loans in the Netherlands was about 350 billion euros. Banks supplied 278 billion euros, institutional investors about 44 billion euros while the remaining 28 billion euros was supplied by others, e.g., foreign financial institutions.

The four largest banks had a total market share of the bank-mortgage market of about 83% on average over the sample period 1997–2003 (authors' calculations). The NMa (2003) reports that in 2000 ABN-Amro had a market share of 20%, Rabobank of 22%, Fortis 12%, and ING Group 25%.

Various types of mortgage loans are available in the Netherlands, ranging from simple annuity loans to security-financed products. Most contracts run for 30 years, with interest renewal negotiations mostly after 1, 2, 5 or 10 years (but also 15, 20 and even 30 years). About half a million new contracts were written in 2002. Two thirds were meant to finance a new house, while one-third was a second mortgage. This paper focuses on the most popular interest rate renewal contracts for 30 year mortgage loans: renewal after 5 and 10 years, respectively. In the remainder of this paper these products are referred to as 5- and 10-year contracts.

2.2 Price-setting behavior by banks

The price setting behavior of the four largest banks is tracked over the years 1997–2003 using daily observations. The data is presented in two ways. First, Table 1 gives the dates of the changes of the interest rates on 5-year contracts. The dating clearly

Table 1 Dates of interest rate changes for 5-year contracts

Year	Bank A	Bank B	Bank C	Bank D
1998	13-Jan-98	13-Jan-98	13-Jan-98	13-Jan-98
				16-Jan-98
	20-Feb-98	19-Feb-98	23-Feb-98	24-Feb-98
				25-Jun-98
	10-Jul-98	20-Jul-98	14-Jul-98	16-Jul-98
	18-Sep-98	18-Sep-98	23-Sep-98	
				2-Sep-98
				26-Oct-98
1999		15-Jan-99	14-Jan-99	20-Jan-99
	14-Apr-99	20-Apr-99	16-Apr-99	
				12-May-99
	9-Jun-99	14-Jun-99	11-Jun-99	11-Jun-99
	7-Jul-99	9-Jul-99	6-Jul-99	6-Jul-99
	4-Aug-99	7-Aug-99	6-Aug-99	6-Aug-99
	14-Oct-99	15-Oct-99	13-Oct-99	19-Oct-99
2000	12-Jan-00	13-Jan-00	13-Jan-00	18-Jan-00
			26-Apr-00	
	10-May-00	12-May-00	12-May-00	
	31-May-00		23-May-00	
				9-Jun-00
	24-Aug-00		6-Sep-00	30-Aug-00
	23-Oct-00			
	20-Dec-00		15-Dec-00	27-Dec-00
2001	19-Jan-01	8-Jan-01	12-Jan-01	19-Jan-01
	4-Apr-01		24-Apr-01	
	23-May-01			
			18-Jun-01	
	10-Aug-01	15-Aug-01	20-Aug-01	17-Aug-01
	28-Sep-01		28-Sep-01	2-Oct-01
	24-Oct-01			2-Nov-01
	7-Nov-01	8-Nov-01	6-Nov-01	13-Nov-01
		26-Nov-01		
	12-Dec-01	14-Dec-01	19-Dec-01	
2002	18-Feb-02	15-Feb-02	12-Feb-02	11-Jan-02
		13-Mar-02		11-Mar-02
	26-Mar-02	8-Apr-02	25-Mar-02	28-Mar-02
	19-Jun-02	8-Jul-02	28-Jun-02	5-Jul-02
	7-Aug-02	15-Aug-02	8-Aug-02	7-Aug-02
	11-Sep-02		20-Sep-02	19-Sep-02
	26-Sep-02		14-Oct-02	
		13-Dec-02		23-Dec-02
2003	15-Jan-03	16-Jan-03	22-Jan-03	21-Jan-03
	12-Feb-03	24-Feb-03		
	17-Mar-03	13-Mar-03	3-Mar-03	3-Mar-03
	26-Mar-03	28-Mar-03		26-Mar-03

shows clustering. The table does not show the magnitude of the changes. Therefore, Fig. 1 presents the time-series of the interest rates set by the four banks together with the capital market funding rate (the interest rate on 5-year government securities). This figure tells the same story as Table 1.

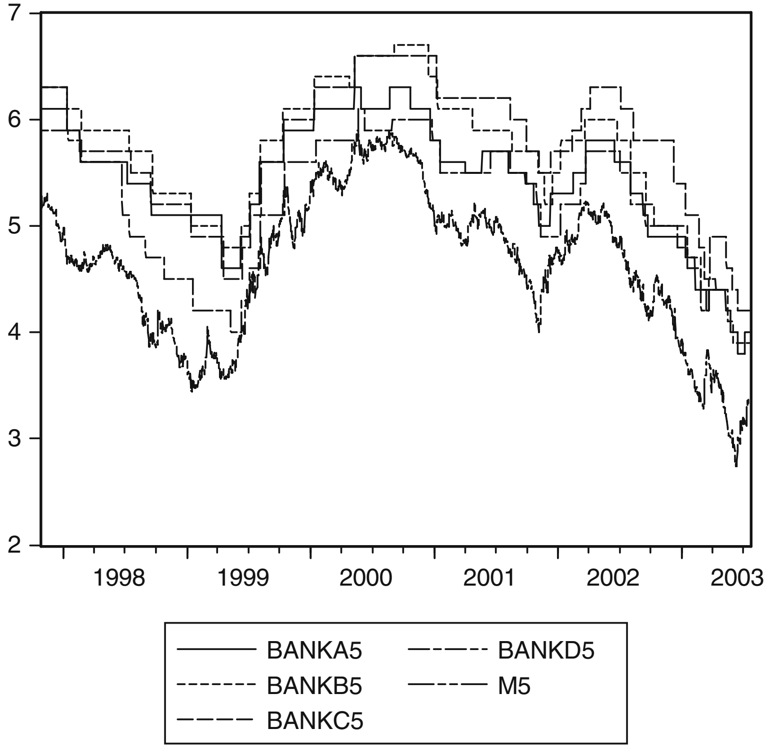

Fig. 1 Interest rates on 5-year mortgage contracts (*bank A to D*) and the market rate. Note: M5 denotes interest rate on government securities with a maturity of 5 years

For 10-year contracts the table and figure look quite similar (and therefore are not reported here). In the analysis hereafter, the results are reported for both products.[3] As the interest rate margin plays a role in the model to be defined in Section 4, Table 2 gives the mean interest rate margins on the two types of contracts. r_i^j is the interest rate on a $j = (5, 10)$-year mortgage contract set by bank $i = A, B, C, D$. $r_{M,t}^j$ is the market funding rate with a maturity j at time t. So the margin is $r_i^j - r_M^j$. Table 2 shows that the interest rate margins differ between banks.[4] Bank D has the lowest interest margin on both 5 and 10 year contracts. Below a linear model is used to describe the long-run cost sensitivity of mortgage rates and the implied interest rate margin. Basically, the bank's mortgage interest rate is modelled as depending on the capital market rate (representing funding cost) plus an intercept, while taking short-run dynamics into account.

[3]It should be noted that a precise comparison between the rates offered by the individual banks can be troubled by the diversity of the products involved.

[4]These differences may reflect relative market power or simply differences in products (note that the latter could also be considered as elements of market power), or even cross-subsidization.

Table 2 Mean interest rate margins (percentage-points). Sample period: 28 October 1997—21 July 2003. Number of observations: 2,025

5-year rates	Margin	10-year rates	Margin
$r_A^5 - r_M^5$	0.808	$r_A^{10} - r_M^{10}$	0.748
$r_B^5 - r_M^5$	1.066	$r_B^{10} - r_M^{10}$	1.000
$r_C^5 - r_M^5$	1.118	$r_C^{10} - r_M^{10}$	1.138
$r_D^5 - r_M^5$	0.583	$r_D^{10} - r_M^{10}$	0.496

3 Literature review

The introduction reviewed some studies on competition in the mortgage market. In this section the focus is on models of (asymmetric) price adjustment. Several theories of asymmetric price adjustments are presented in the literature. Focusing on the relevant ones for the banking sector, the first reason for asymmetric price adjustment is that if concentration in a market is high, due to e.g. entry barriers, there is a scope for price coordination. Tacit collusion can occur with full or partial information on the input prices of all the players in the market. A second cause of asymmetric pricing may be the existence of consumer search costs. If searching for a lower price is costly, firms can exploit this. Also, if consumers face a signal extraction problem and output prices are volatile, the expected gains from searching by the consumer are low. Third, price adjustment cost, so-called menu costs, may cause price adjustment asymmetries. Finally, banks incur a so-called offer cost. Clients that have received a mortgage contract offer from a bank still benefit from a subsequent interest rate decrease within the contract offer period, while not being confronted with any interest rate increases. Banks have to bear the costs unilaterally, which creates an asymmetry in pricing (see Toolsema 2003).

There is an extensive empirical literature on asymmetric price responses to cost shocks in the banking sector. Neumark and Sharpe (1992) present evidence for consumer deposit markets and link their empirical evidence of asymmetric pricing to market concentration. Allen et al. (1999), Haney (1988), Hofmann and Mizen (2004) and Toolsema and Jacobs (2007) find evidence of asymmetric pricing in the mortgage market.

Hofmann and Mizen (2004) analyse the UK banking market using data on 90-day deposits and mortgages for seven banks. They report incomplete pass-through for rates on thirteen deposit and mortgage products offered by individual UK financial institutions. The speed of adjustment in retail rates depends on whether the perceived gap between retail and base rates is widening or narrowing. The pattern of responses supports the theory that financial institutions respond more to widening gaps than to narrowing gaps.

Arbatskaya and Baye (2004) present microeconomic evidence of an electronic market for mortgage loans for the US. They find that prices are much less sticky in electronic markets as compared to traditional retail outlets. But even in electronic markets cost increases are passed on to consumers about twice as quickly as cost decreases.

The study by Toolsema and Jacobs (2007) is highly relevant to the present one since it analyzes the case of the Dutch mortgage market. Using a macro-aggregate measure of the Dutch mortgage rate, they find downward rigidity of the mortgage interest rate. They conclude that the interest rate offer set by banks on new loans is rigid downwards. The contribution of the present paper is the use of Dutch mortgage market data with a daily frequency and for individual banks. Micro-data evidence for the Dutch mortgage market is still lacking as far as we know. These data are available for the UK markets; recent work in this field is done by Fuertes and Heffernan (2009) and Fuertes et al. (2010). Fuertes and Heffernan (2009) test for heterogeneities in the interest rate transmission mechanism, using a large sample of 662 monthly retail rates on seven deposit and loan products for the UK banking market. The evidence reported indicates between-product heterogeneity but notable differences were found between financial firms in the way they adjust their rates. Heterogeneity in adjustment is found to be linked to menu costs and key financial ratios. The adjustment speed of savings rates is significantly faster than that of mortgage rates: this is consistent with the general view that the downward adjustment of retail rates is faster for savings than mortgages. Fuertes et al. (2010) explore the interest rate transmission mechanism using a broad disaggregated sample of UK deposit and credit products for the period 1993–2005. The dataset consists of 662 disaggregated, bank-specific monthly rates on savings and current accounts, unsecured personal loans, mortgages, credit cards and store cards. They find a faster adjustment toward the long run path when the policy rate revision widens the gap. Large gaps lead to a disproportionately faster correction, mainly for deposits. The magnitude of the policy rate change also impacts the adjustment speed. The heterogeneity across financial institutions and products is explained to some extent by diversification, profit volatility, product range, market concentration and the existence of menu costs. Market concentration and profit volatility emerge as significant determinants of nonlinear adjustment.

The literature shows that the issue of pass-through and asymmetric adjustment is alive and relevant. The impact of monetary policy via changes in policy rates is fully dependent on the interest rate adjustment behavior of private banks. The recent evidence for the UK illustrates that asymmetric adjustment is found and that there might be a link with bank concentration or imperfect competition. However, apart from the study by Toolsema and Jacobs (2007), which uses aggregate data on a monthly basis, little is known about the Dutch mortgage market. Our contribution is the first to focus on daily interest rate adjustment using micro-evidence for the Dutch market.

4 Econometric methodology

Prior to estimating the models, the time series properties of the interest rates used are tested. Special attention should thereby not only go to testing stationarity but also to the presence of clustered volatility, which is a common characteristic of high-frequency data such as used in this paper. The results of this pretesting information are then used for estimating the model. The model assumes that, in the long run, banks set mortgage rates as a mark-up on funding costs (Toolsema and Jacobs 2007):

$$r^j_{i,t} = \alpha^j_i + \beta^j_i r^j_{M,t} + \epsilon^j_{i,t} \tag{1}$$

where $r^j_{i,t}$ is the interest rate on a $j = (5, 10)$-year mortgage contract set by bank $i = A, B, C, D$ at time t, $r^j_{M,t}$ is the market funding rate with a maturity j at time t, and α_i^j, β_i^j are bank-specific and contract-maturity specific mark-up and pass-through parameters, respectively. $\epsilon_{i,t}^j$ is a residual, which may contain ARCH-effects as a result of the daily frequency of the data. Therefore the long-run parameters are estimated correcting for possible ARCH-effects. Next, an Error Correction Model (ECM) is specified to capture both the short-run and long-run dynamics. Following Geweke (2004), two types of asymmetric price adjustment in the short run are allowed for. Suppose the short-run dynamics including asymmetries in first differences are captured by:

$$\Delta\left(r_{i,t}^j\right) = \sum_{s=0}^{T} \lambda_{i,s}^{+} \Delta r_{M,t-s}^{j,+} + \sum_{s=0}^{T} \lambda_{i,s}^{-} \Delta r_{M,t-s}^{j,-} + \omega_i^{j,+} \widehat{\epsilon_{i,t-1}^{j,+}} + \omega_i^{j,-} \widehat{\epsilon_{i,t-1}^{j,-}} + u_{i,t}^j \tag{2}$$

where the error correction parameters $\omega_i^+, \omega_i^- < 0$, $\hat{\epsilon}$ are the residuals from Eq. 1 and $\lambda_{i,s}^+, \lambda_{i,s}^-$ are the (positive) parameters of adjustment to capital market interest rate changes. The superscripts $+$ and $-$ refer to the positive part and negative part of the time series, respectively. For example, for $\Delta r_{M,t}$:

$$\Delta r_{M,t}^{+} = \begin{cases} \Delta r_{M,t} & \text{if } \Delta r_{M,t} > 0 \\ 0 & \text{if } \Delta r_{M,t} < 0 \end{cases} \tag{3}$$

and

$$\Delta r_{M,t}^{-} = \begin{cases} 0 & \text{if } \Delta r_{M,t} > 0 \\ \Delta r_{M,t} & \text{if } \Delta r_{M,t} < 0 \end{cases} \tag{4}$$

The first two sets of terms in Eq. 2 are current and lagged capital market interest rate increases and decreases, respectively. Since daily observations with irregular, infrequent and discrete jumps are used (see Fig. 1), the short-run parameters cannot be estimated independently. Therefore, the Moving Average (MA) operator is used:

$$MA(x, T) = \frac{\Sigma_{s=0}^{T-1} x_{-s}}{T} \tag{5}$$

The intuition is that the variance of the short-run changes in the market rates decreases if the number of lags increases. Hence, the model for each bank i is as follows:

$$\Delta\left(r_{i,t}^j\right) = \lambda_i^{j,+} MA\left(\Delta r_{M,t-s}^{j,+}, T\right) + \lambda_i^{j,-} MA\left(\Delta r_{M,t-s}^{j,-}, T\right) + \omega_i^{j,+} \widehat{\epsilon_{i,t-1}^{j,+}} + \omega_i^{j,-} \widehat{\epsilon_{i,t-1}^{j,-}} + u_{i,t}^j \tag{6}$$

Two forms of asymmetric adjustment are considered. First, it is possible that there is asymmetric adjustment to the capital market interest rate changes, so-called *amount asymmetry* in the short run. There is short-run amount asymmetry if $\lambda_i^+ \neq \lambda_i^-$. Secondly, the adjustment process toward the long run can be asymmetrical. This so-called *adjustment asymmetry* is present if $\omega_i^+ \neq \omega_i^-$.[5] The relevance of these asymmetries for competition is that the amount and adjustment asymmetries will be

[5] In theory, the effects of shocks to volatility can be asymmetric as well (see Bettendorf et al. 2009). One can for instance assume that the residuals in the short-run specification follow an EGARCH-process. Since our dependent variables do not demonstrate ARCH-effects (according to the tests for ARCH-presence in the ECMs), we refrain from the latter type of asymmetry.

more relevant for the market leader than for the Stackelberg followers. A dominant bank is expected to be able to maintain its mark-up longer than its rivals. This would imply that dominant market participants pass through market interest rate increases more quickly than market interest rate decreases ($\lambda^+ > \lambda^-$) and that a positive gap between the model-based and actual interest rate in the previous period (leading to a negative estimated residual) leads to a swifter error correction than a negative gap ($|\omega^-| > |\omega^+|$).

5 Results

5.1 Stationarity and clustered volatility of the series

First, the interest rate time series are tested for stationarity. Since the bank interest rates are constant in short intervals with discrete jumps (see Fig. 1), the process is not typically standard. Table 3 presents results of Augmented–Dickey–Fuller and Phillips–Perron tests for stationarity for the 5-year capital market interest rate (r_M^5) and the interest rate on 5-year mortgage contracts of Bank A. Both series are of order $I(1)$ and the other interest rates exhibit the same property. Next, cointegration between bank A's mortgage interest rate and the capital market rate is tested. Table 4 shows that there indeed is cointegration. Similar results apply to the interest rates of Bank B, C and D (therefore not reported here).

The mortgage interest rates set by banks do not demonstrate clustered volatility (by definition). However, the two market interest rates might show clustered volatility. Table 5 shows some significant autocorrelations of $\Delta(r_M^j)$ and $(\Delta(r_M^j))^2$, where $j = 5, 10$. A positive and slowly decaying autocorrelation function could establish clustered volatility. However, this is not found for both capital market interest rates. By way of precaution the residuals of both long-run and short-run models will be tested for ARCH-effects, though.

Table 3 Augmented Dickey–Fuller and Phillips–Perron unit root tests

	r_M^5	Δr_M^5	r_A^5	Δr_A^5
Augmented Dickey–Fuller test				
Exogenous	None	None	None	None
Lag length (SIC)	0	0	0	0
ADF test statistic	−1.094	−47.169	−1.428	−45.717
Critical values 5% level	−1.941	−1.941	−1.941	−1.941
p-value*	0.249	0.000	0.143	0.000
Observations	2091	2090	2092	2091
Null of unit root	Not rejected	Rejected	Not rejected	Rejected
Phillips–Perron test				
Exogenous	None	None	None	None
Bandwidth	6	4	1	0
P-P test statistic	−1.095	−47.145	−1.429	−45.717
Critical values 5% level	−1.941	−1.941	−1.941	−1.941
p-value*	0.248	0.000	0.143	0.000
Observations	2091	2090	2092	2091
Null of unit root	Not rejected	Rejected	Not rejected	Rejected

*MacKinnon (1996) one-sided p -values

Table 4 Johansen cointegration test

Series	r_A^5, r_M^5			
Trend assumption	No deterministic trend			
Lags	2			
Observations	2089			
Unrestricted cointegration rank test (trace)				
Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	5% critical value	p-value**
None*	0.042	91.107	25.872	0.000
At most 1	0.001	1.835	12.518	0.978
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized no. of CE(s)	Eigenvalue	Max-eigen statistic	5% critical value	p-value**
None*	0.042	89.272	19.387	0.000
At most 1	0.001	1.835	12.528	0.978

*Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon et al. (1999) p-values

5.2 Pass-through of costs in the long run

The long-run parameters α^j and β^j are estimated for each bank using a pairwise ARCH(1) model of r_i^j on r_M^j (see Eq. 1). First, the long-run model is estimated by OLS. Table 6 shows that there is incomplete pass-through and a significant mark-up for 5-year contract pricing by bank A (note that β^j differs significantly from unity). The reported ARCH-LM test indicates that there are ARCH-effects present in the residuals. Therefore, the model is reestimated using an ARCH(1)-specification. Table 7 illustrates that the magnitude of the parameters is not significantly affected by the ARCH-correction (as compared to the OLS-results). Table 8 presents condensed information on the results for the four banks and the two contracts, in line with Table 7. It gives the parameter estimates of all the cointegrating vectors, corrected for ARCH. From this table the following conclusions can be derived:

1. The four Dutch banks set their prices competitively, as β^j is significantly positive;
2. Banks A and D typically follow the market rate less closely than banks B and C (as shown by the lower estimates of β^j);

Table 5 Autocorrelations of first differences and squared first differences of r_M^5 and r_M^{10}. Two standard error bounds are computed as $\pm 2/\sqrt{T} = \pm 0.044$, with $T = 2{,}091$

Lag	$\Delta(r_M^5)$	$(\Delta(r_M^5))^2$	$\Delta(r_M^{10})$	$(\Delta(r_M^{10}))^2$
1	−0.031	0.117	−0.039	0.135
2	0.044	−0.005	0.035	−0.001
3	−0.007	0.007	−0.023	0.002
4	0.008	0.004	−0.007	0.021
5	−0.029	−0.007	−0.032	−0.008
6	0.016	0.054	0.011	0.071
7	−0.023	0.115	−0.034	0.097
8	0.026	0.068	0.025	0.070
9	−0.001	0.020	−0.007	−0.001
10	−0.012	0.016	0.025	0.028

Table 6 Long-run OLS results

$r_A^5 = \alpha_A^5 + \beta_A^5 r_M^5 + \eta_t$	Coefficient	(t-value)
α_A^5	2.055	(110.09)
β_A^5	0.732	(65.929)
Observations	2092	
Adjusted R^2	0.853	
S.E. of regression	0.213	
F-statistic (p-value)	12120.6	(0.000)
Durbin–Watson	0.042	
ARCH-LM-test (p-value)	7493.98	(0.000)
Wald test	F-statistic	(p-value)
$H_0 : \beta_A^5 = 1$ (df = 2090)	1627.55	(0.000)
$H_0 : \alpha_A^5 = 0, \beta_A^5 = 1$ (df = 2090)	15.945	(0.000)

3. Bank B has β-parameters closer to unity and thus follows the market most closely;
4. The mark-up parameter α is highest for Bank A and Bank C. However, since it may concern heterogeneous products in terms of non-interest rate conditions in the contracts, the estimated mark-ups do probably not allow inference concerning market power.

It follows from the long-run analysis that Bank A and Bank D seem to set interest rates more independently of market developments than Bank B and Bank C. This should be kept in mind for the analysis of short-run asymmetric price adjustment. The estimated residuals from the long-run models will be used in the corresponding short-run ECM-models hereafter.

5.3 Asymmetric pass-through

The next step is to estimate the short-run Error Correction Model (6) for the 5- and 10-year contracts and the four banks. The differences between the λ_i-parameters in model (6) indicate amount asymmetry, while the differences between the ω_i-parameters denote adjustment asymmetry. In line with Toolsema and Jacobs (2007), our priors are that $\lambda^+ > \lambda^-$ and $|\omega^-| > |\omega^+|$. There is an arbitrary choice of the number of lags T to be used in the moving average term. We experiment with 15 days

Table 7 Long-run ARCH(1) results

$r_A^5 = \alpha_A^5 + \beta_A^5 r_M^5 + \eta_t$	Coefficient	(z-value)
α_A^5	2.104	(352.58)
β_A^5	0.723	(552.03)
Observations	2092	
Adjusted R^2	0.852	
S.E. of regression	0.214	
F-statistic (p-value)	4024.28	(0.000)
Durbin–Watson	0.042	
ARCH-LM-test (p-value)	0.138	(0.968)
Wald test	F-statistic	(p-value)
$H_0 : \beta_A^5 = 1$ (df = 2085)	44630.59	(0.000)
$H_0 : \alpha_A^5 = 0, \beta_A^5 = 1$ (df = 2085)	453878.0	(0.000)

Table 8 Long-run ARCH(1) parameters

5-year	α^5	β^5	10-year	α^{10}	β^{10}
r_A^5	2.104	0.723	r_A^{10}	2.315	0.682
r_B^5	1.744	0.829	r_B^{10}	1.945	0.818
r_C^5	2.223	0.758	r_C^{10}	2.538	0.738
r_D^5	1.939	0.710	r_D^{10}	1.717	0.760

and 30 days, respectively. The variance of the moving average of the market interest rate changes decreases in lag length. Tables 9, 10, 11 and 12 give the estimation results for the four banks for the 5- and 10-year contracts, both for the 15- and 30-day moving average transformation of the amount terms. Hence, there are 16 estimated models in total.

In general, the Error Correction Model fits the data reasonably well. The estimated λ's are positive while the ω's are negative, in line with the assumptions. Most of them are statistically significant, the ω's more so than the λ's.

The Wald tests merit particular attention as measures of amount and adjustment asymmetry. The evidence is weak. Employing generous significance levels up to 10%, only five out of the 16 estimated models show evidence of amount asymmetry ($\lambda^+ \neq \lambda^-$). Four of these cases concern Bank A and Bank D (both for 5-year contracts), the fifth case refers to Bank B (10-year contract, T = 15). However, contrary to expectations, in all of these cases banks respond more strongly to decreases in market interest rates than to increases ($\lambda^+ < \lambda^-$). This suggests more rather than less competition.

Table 9 Error Correction Model estimation results for 5-year contracts ($T = 15$)

$\Delta(r_{i,t}^5) = \lambda_i^{5,+} MA(\Delta r_{M,t-s}^{5,+}, 15) + \lambda_i^{5,-} MA(\Delta r_{M,t-s}^{5,-}, 15) + \omega_i^{5,+} RES_{i,t-1}^{5,+} + \omega_i^{-} RES_{i,t-1}^{5,-} + \epsilon_{i,t}$

	Bank A	Bank B	Bank C	Bank D
$\lambda_i^{5,+}$	0.179	0.094	0.117	0.057
$\sigma(\lambda_i^{5,+})$	(0.090)	(0.122)	(0.109)	(0.106)
$\lambda_i^{5,-}$	0.324	0.230	0.177	0.261
$\sigma(\lambda_i^{5,-})$	(0.090)	(0.123)	(0.103)	(0.096)
$\omega_i^{5,+}$	−0.010	−0.015	−0.022	−0.010
$\sigma(\omega_i^{5,+})$	(0.006)	(0.006)	(0.007)	(0.005)
$\omega_i^{5,-}$	−0.023	−0.022	−0.022	−0.026
$\sigma(\omega_i^{5,-})$	(0.007)	(0.006)	(0.007)	(0.006)
Observations	2077	2077	2077	2010
Adjusted R^2	0.023	0.022	0.031	0.026
S.E. of Regression	0.033	0.033	0.036	0.035
Durbin–Watson	2.016	2.010	2.020	2.016
ARCH LM-test	0.274	0.226	0.204	0.167
(p-value)	(0.601)	(0.635)	(0.652)	(0.683)
Wald test: F-statistic				
$H_0: \lambda_i^{5,+} = \lambda_i^{5,-}$ v $H_1: \lambda_i^{5,+} \neq \lambda_i^{5,-}$	2.860	2.442	0.397	4.892
(p-value)	(0.091)	(0.118)	(0.528)	(0.027)
$H_0: \omega_i^{5,+} = \omega_i^{5,-}$ v $H_1: \omega_i^{5,+} \neq \omega_i^{5,-}$	1.524	0.505	0.027	2.993
(p-value)	(0.217)	(0.478)	(0.869)	(0.084)

Table 10 Error Correction Model estimation results for 5-year contracts ($T = 30$)

$\Delta(r^5_{i,t}) = \lambda_i^{5,+} MA(\Delta r^{5,+}_{M,t-s}, 30) + \lambda_i^{5,-} MA(\Delta r^{5,-}_{M,t-s}, 30) + \omega_i^{5,+} RES^{5,+}_{i,t-1} + \omega_i^{-} RES^{5,-}_{i,t-1} + \epsilon_{i,t}$

	Bank A	Bank B	Bank C	Bank D
$\lambda_i^{5,+}$	0.411	0.249	0.204	0.201
$\sigma(\lambda_i^{5,+})$	(0.114)	(0.122)	(0.149)	(0.146)
$\lambda_i^{5,-}$	0.562	0.355	0.259	0.367
$\sigma(\lambda_i^{5,-})$	(0.112)	(0.123)	(0.149)	(0.135)
$\omega_i^{5,+}$	−0.007	−0.014	−0.021	−0.023
$\sigma(\omega_i^{5,+})$	(0.006)	(0.006)	(0.007)	(0.006)
$\omega_i^{5,-}$	−0.023	−0.019	−0.022	−0.023
$\sigma(\omega_i^{5,-})$	(0.007)	(0.007)	(0.007)	(0.006)
Observations	2062	2062	2062	1995
Adjusted R^2	0.028	0.023	0.031	0.026
S.E. of Regression	0.033	0.033	0.036	0.035
Durbin–Watson	2.029	2.017	2.023	2.022
ARCH LM-test	0.262	0.228	0.210	0.168
(p-value)	(0.608)	(0.633)	(0.647)	(0.682)
Wald test: F-statistic				
$H_0 : \lambda_i^{5,+} = \lambda_i^{5,-}$ v $H_1 : \lambda_i^{5,+} \neq \lambda_i^{5,-}$	2.915	1.409	0.322	3.050
(p-value)	(0.088)	(0.235)	(0.570)	(0.081)
$H_0 : \omega_i^{5,+} = \omega_i^{5,-}$ v $H_1 : \omega_i^{5,+} \neq \omega_i^{5,-}$	2.073	0.263	0.035	1.943
(p-value)	(0.150)	(0.608)	(0.852)	(0.163)

Table 11 Error Correction Model estimation results for 10-year contracts ($T = 15$)

$\Delta(r^{10}_{i,t}) = \lambda_i^{10,+} MA(\Delta r^{10,+}_{M,t-s}, 15) + \lambda_i^{10,-} MA(\Delta r^{10,-}_{M,t-s}, 15) + \omega_i^{10,+} \hat{\epsilon}^{10,+}_{i,t-1} + \omega_i^{10,-} \hat{\epsilon}^{10,-}_{i,t-1} + u_{i,t}$

	Bank A	Bank B	Bank C	Bank D
$\lambda_i^{10,+}$	0.200	0.027	0.059	−0.016
$\sigma(\lambda_i^{10,+})$	(0.092)	(0.090)	(0.105)	(0.105)
$\lambda_i^{10,-}$	0.269	0.182	0.161	0.108
$\sigma(\lambda_i^{10,-})$	(0.090)	(0.084)	(0.090)	(0.100)
$\omega_i^{10,+}$	−0.011	−0.016	−0.036	−0.014
$\sigma(\omega_i^{10,+})$	(0.005)	(0.005)	(0.007)	(0.005)
$\omega_i^{10,-}$	−0.026	−0.026	−0.022	−0.030
$\sigma(\omega_i^{10,-})$	(0.009)	(0.007)	(0.006)	(0.007)
Observations	2077	2077	2077	2010
Adjusted R^2	0.022	0.025	0.032	0.022
S.E. of Regression	0.032	0.030	0.032	0.033
Durbin–Watson	2.017	2.009	2.095	2.003
ARCH LM-test	0.073	0.178	0.082	0.035
(p-value)	(0.788)	(0.674)	(0.774)	(0.851)
Wald test: F-statistic				
$H_0 : \lambda_i^{10,+} = \lambda_i^{10,-}$ v $H_1 : \lambda_i^{10,+} \neq \lambda_i^{10,-}$	0.815	3.832	1.786	2.177
(p-value)	(0.367)	(0.050)	(0.185)	(0.140)
$H_0 : \omega_i^{10,+} = \omega_i^{10,-}$ v $H_1 : \omega_i^{10,+} \neq \omega_i^{10,-}$	2.619	0.981	1.994	3.243
(p-value)	(0.141)	(0.322)	(0.158)	(0.072)

Table 12 Error Correction Model estimation results for 10-year contracts ($T = 30$)

$\Delta(r_{i,t}^{10}) = \lambda_i^{10,+} MA(\Delta r_{M,t-s}^{10,+}, 30) + \lambda_i^{10,-} MA(\Delta r_{M,t-s}^{10,-}, 30) + \omega_i^{10,+} \hat{\epsilon_{i,t-1}^{10,+}} + \omega_i^{10,-} \hat{\epsilon_{i,t-1}^{10,-}} + u_{i,t}$

	Bank A	Bank B	Bank C	Bank D
$\lambda_i^{10,+}$	0.377	0.038	0.118	0.028
$\sigma(\lambda_i^{10,+})$	(0.123)	(0.128)	(0.147)	(0.152)
$\lambda_i^{10,-}$	0.420	0.165	0.190	0.121
$\sigma(\lambda_i^{10,-})$	(0.124)	(0.165)	(0.131)	(0.147)
$\omega_i^{10,+}$	−0.012	−0.018	−0.039	−0.015
$\sigma(\omega_i^{10,+})$	(0.004)	(0.005)	(0.008)	(0.005)
$\omega_i^{10,-}$	−0.024	−0.025	−0.020	−0.028
$\sigma(\omega_i^{10,-})$	(0.009)	(0.007)	(0.006)	(0.007)
Observations	2062	2062	2062	1995
Adjusted R^2	0.024	0.024	0.033	0.022
S.E. of Regression	0.032	0.029	0.033	0.022
Durbin–Watson	2.023	2.007	2.011	2.004
ARCH LM-test	0.072	0.182	0.082	0.036
(p-value)	(0.790)	(0.670)	(0.775)	(0.850)
Wald test: F-statistic				
$H_0 : \lambda_i^{10,+} = \lambda_i^{10,-}$ v $H_1 : \lambda_i^{10,+} \neq \lambda_i^{10,-}$	0.289	2.408	0.856	1.144
(p-value)	(0.591)	(0.121)	(0.355)	(0.285)
$H_0 : \omega_i^{10,+} = \omega_i^{10,-}$ v $H_1 : \omega_i^{10,+} \neq \omega_i^{10,-}$	1.288	0.376	3.445	2.071
(p-value)	(0.256)	(0.540)	(0.064)	(0.150)

Three out of the 16 estimated models show significant evidence of adjustment asymmetry ($\omega^- \neq \omega^+$), two of which concern Bank D (T = 15). In accordance with expectations, Bank D is more eager to adjust its interest rates if the desired level exceeds the actual rate. The third case of evidence of adjustment asymmetry concerns Bank C (10-year contract, T = 30), but its adjustment asymmetry is opposite to the hypothesized one.

6 Conclusion

This paper presents an empirical analysis of the interest rate setting behavior of the four largest banks in the Dutch mortgage market, using advertised interest rates at a daily frequency. The evidence for the long run pricing behaviour suggests that the banks operate in a competitive environment as they base their interest rates on funding cost. However, two banks appear to be less cost sensitive than the others. In the short run, most of the banks adjust their rates less strongly to funding cost increases than to decreases, which suggests competitive pressures. For one bank significant evidence is found for a quicker response to negative than to positive deviations of actual from desired interest rates.

From a monetary policy's perspective heterogeneity in both long-run and short-run price adjustment to money market rate changes might be troublesome if it leads to unexpectedly large dispersions in retail mortgage interest rates. The magnitudes of the differences in the estimated parameters do not suggest such a large dispersion, though. From a competition authority's perspective, there is little reason to worry about the Dutch mortgage market. In the long run, bank supply of mortgages appears to be competitive as interest rates are set on the basis of funding costs, although two banks show lower pass-through rates than the other two. In the short run, most of the banks adjust their rates less strongly to funding cost increases than to decreases, which is advantageous to consumers.

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References

Allen MT, Rutherford RC, Wiley MK (1999) The relationships between mortgage rates and capital-market rates under alternative market conditions. J Real Estate Finance Econ 19:211–221
Arbatskaya M, Baye MR (2004) Are prices ‘sticky’ online? Market structure effects and asymmetric responses to cost shocks on online mortgage markets. Int J Ind Organ 22:1443–1462
Bettendorf L, van der Geest SA, Kuper GH (2009) Do daily retail gasoline prices adjust asymmetrically? J Appl Stat 36:385–397
Bikker JA, Haaf K (2002) Competition, concentration and their relationship: an empirical analysis of the banking industry. J Bank Financ 26:2191–2214
Corvoisier S, Gropp R (2002) Bank concentration and retail interest rates. J Bank Financ 26: 2155–2189
Degryse H, Ongena SR (2005) Distance, lending relations, and competition. J Finance 60:231–266
Freixas X, Rochet J-C (eds) (1997) Microeconomics of banking. MIT, Cambridge
Fuertes AM, Heffernan SA (2009) Interest rate transmission in the UK: a comparative analysis across financial firms and products. Int J Financ Econ 14:45–63
Fuertes AM, Heffernan SA, Kalotychou E (2010) How do UK banks react to changing central bank rates? J Financ Serv Res 37:99–130
Geweke J (2004) Issues in the “Rockets and Feathers” gasoline price literature. Report to Federal Trade Commission, University of Iowa
Gual J, Neven DJ (1993) Deregulation in the European banking industry: 1980–1990. Eur Econ 3:151–183
Haney RL (1988) Sticky mortgage rates: some empirical evidence. J Real Estate Res 3:61–73
Hassink W, van Leuvenstein M (2003) Price setting and price dispersion in the Dutch mortgage market. CPB Discussion Paper 21, Netherlands Bureau for Economic Policy Analysis
Hofmann B, Mizen P (2004) Interest rate pass-through and monetary transmission: evidence from individual financial institutions’ retail rates. Economica 71:99–123
MacKinnon JG (1996) Numerical distribution functions for unit root and cointegration tests. J Appl Econ 11(6):601–618
MacKinnon JG, Haug AA, Michelis L (1999) Numerical distribution functions of likelihood ratio tests for cointegration. J Appl Econ 14(5):563–577
Mojon B (2001) Financial structure and the interest rate channel of ECB monetary policy. Econ Prévis 147:89–115
Nederlandse Mededingingsautoriteit (NMa) (ed) (2003) Monitor financiële sector 2003. NMa, The Hague
Neumark D, Sharpe SA (1992) Market structure and the nature of price rigidity: evidence from the market for consumer deposits. Q J Econ 107:657–680
Toolsema LA (2003) On competition and banking. PhD thesis, University of Groningen
Toolsema LA, Jacobs JPAM (2007) Why do prices rise faster than they fall? With an application to mortgage rates. Manage Decis Econ 28:701–712